4. SELECTION OF GENERIC CASKS

4.1 Description of Casks

Generic casks were used in this study to relate the behavior of typical examples of a broad packaging type to the risks that might be realized during a spent fuel shipping campaign. Detailed analyses of these casks can be used to demonstrate differences (or similarities) among various construction features for this type of package. Casks for the transportation of power reactor fuel are generally available in three weight classes (legal weight truck, overweight truck, and rail) and with three gamma-shielding materials (steel, lead, and depleted uranium). Casks that are most likely to be used in future shipping campaigns only use four of the nine possible combinations of weight and shielding. These are lead and depleted uranium (DU) shielded truck casks and steel and lead shielded rail casks. A survey of currently licensed and proposed casks was used to develop the generic casks used for this study. Tables 4.1 to 4.4 list the casks that were examined to develop generic designs. Most of the information was obtained from "Shipping and Storage Cask Data for Commercial Spent Nuclear Fuel," by JAI Corporation [4-1]. Other information was obtained from the certificates of compliance for the casks or from safety analysis reports.

Tables 4.1 to 4.4 list the casks used in derivation of the generic casks and provide details about the generic casks. Because of the way the generic casks were developed, they may not meet all of the requirements of 10 CFR 71. Real packages must meet these requirements, and are therefore, likely to be more robust than the generic casks used in this study. For the monolithic steel rail casks, the currently licensed casks use some type of ferritic steel for the cask body and lid. The current regulatory position favors the use of stainless steel or a ferritic steel with very high ductility (requirements are given in NRC Regulatory Guide 7.12 [4-2]). For this reason, and to be consistent with the sandwich wall casks, stainless steel was chosen as the material for the monolithic cask. Figures 4.1 to 4.4 show artist renditions of the generic casks. Other features that are typical of transportation casks but are not included in the generic casks are fill and drain ports, lifting and tiedown trunnions, and personnel barriers. The omission of these features is not believed to significantly effect the behavior of the casks. The personnel barrier absorbs energy during an impact and acts as a thermal shield during a fire event. Therefore, omitting this feature is conservative. For the extra-regulatory impacts considered in this report, impact onto a trunnion is less damaging than impact onto the side of the cask, as the impact area is smaller and the trunnion will act as an impact limiter. Therefore, omitting this feature is also conservative. The fill and drain ports are generally in the very substantial base and lid structure of the cask. These are regions with small deformations, and it is very unlikely that a failure will occur at these points.

Table 4.1 Steel-Lead-Steel Truck Casks

Name	Weight (pounds)	Material	Closure Bolts (no./size)	Wall Thickness (inches)	Outside Diameter (inches)	Cavity Diameter (inches)	Length (inches)	Impact Limiter	Design Heat Rejection (kW)	Seal Material	C of C
NAC-LWT	52,000	stainless	12 1”	0.75,5.75,1.2	44.2	13.375	199.80	honeycomb	2.5	both	71-9225
NAC-1	49,000	stainless	6 1.25”	0.31,6.63,1.25	38	13.5	214	balsa	11.5	elast.	71-9183
NLI-1/2*	49,250	stainless	12 1”	0.5,2.125Pb, 2.75DU,0.875	47.125	13.375	195.25	balsa	10.6	metal	71-9010
TN-8**	79,200	steel	16 1.25”	0.23,5.32,0.79	67.6	~30	217.2	balsa	35.5	elast.	71-9015
TN-9**	79,200	steel	16 1.25”	0.23,5.04,0.79	67.6	~21	226.6	balsa	24.5	elast.	71-9016
TN-FSV	47,000	stainless	12 1”	1.12,3.44,1.5	31.0	18.0	207	wood	0.36	elast.	71-9253
Modal Study	N.A.	stainless	N.A.	0.5,5.25,1.25	27.5	13.5	193	yes	0.8-5.4	N.A.	-
Generic	**50,000**	**stainless**	**12 1”**	**0.5,5.5,1.0**	**27.5**	**13.5**	**205**	**yes**	**2.5**	**elast.**	**-**

* This cask has a steel-lead-DU-steel wall configuration and was therefore not used in the determination of the generic cask.
** These casks are overweight-truck casks and were therefore not used in the determination of the generic cask.

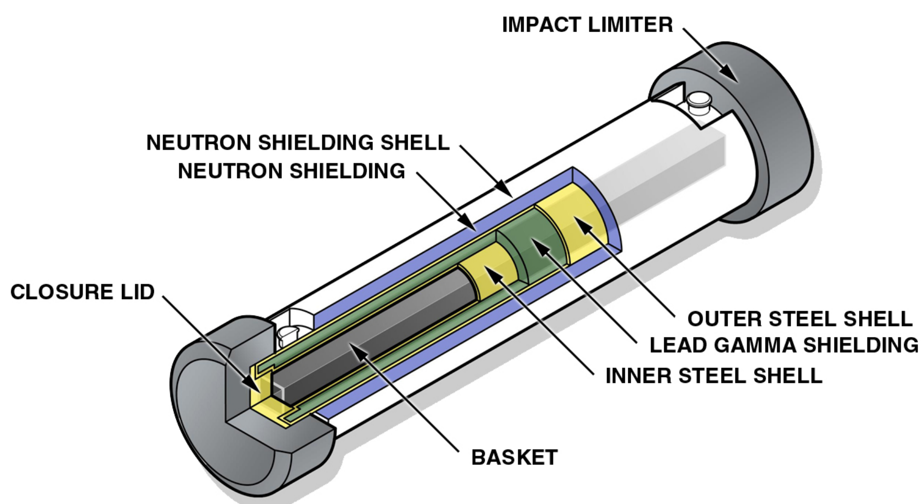

Figure 4.1 Conceptual design of a generic steel-lead-steel truck cask.

Table 4.2 Steel-DU-Steel Truck Casks

Name	Weight (pounds)	Material	Closure Bolts (no./size)	Wall Thickness (inches)	Outside Diameter (inches)	Cavity Diameter (inches)	Length (inches)	Impact Limiter	Design Heat Rejection (kW)	Seal Material	C of C
FSV-1	47,600	stainless	24 1.25”	0.67,3.5,0.91	28.0	17.7	208	yes	4.1	elast.	71-6346
GA-4	53,610	stainless	12 1”	0.375,2.64,1.5	39.75	18.16 sq.	187.75	honeycomb	2.47	elast.	71-9226
GA-9	54,000	stainless	12 1”	0.25,2.45,1.75	39.75	18.16 sq.	198.3	honeycomb	2.12	elast.	-
NLI-1/2*	49,250	stainless	12 1”	0.5,2.125Pb, 2.75DU,0.875	47.125	13.375	195.25	balsa	10.6	metal	71-9010
Generic	**50,000**	**stainless**	**12 1”**	**0.5,3.5,0.9**	**28**	**18**	**200**	**yes**	**2.5**	**elast.**	**-**

* This cask has a steel-lead-DU-steel wall configuration and was therefore not used in the determination of the generic cask.

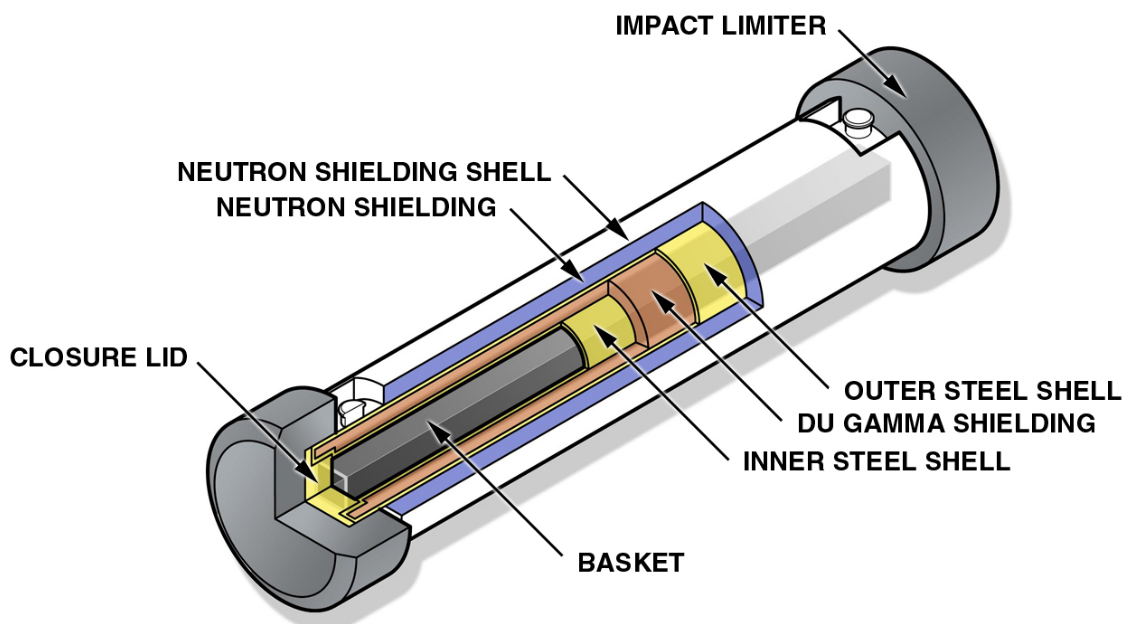

Figure 4.2 Conceptual design of a generic steel-DU-steel truck cask.

Table 4.3 Steel-Lead-Steel Rail Casks

Name	Weight (pounds)	Material	Closure Bolts (no./size)	Wall Thickness (inches)	Outside Diameter (inches)	Cavity Diameter (inches)	Length (inches)	Impact limiter	Design Heat Rejection (kW)	Seal Material	C of C
NAC-STC	250,000	stainless	42 1.5”	1.5,3.7,2.65	87.0	71.0	193	wood	22.3	metal	71-9235
TranStor	244,000	stainless	N.A.	N.A.	87.0	67.0	210.0	honeycomb	26	metal	-
125B	181,500	stainless	32 1.5”	1.0,3.88,2.0	65.5	51.25	207.5	foam	0.7	elast.	71-9200
Excellox-6	194,000	ferritic steel	N.A.	N.A.	83.23	32.8	200.5	yes	N.A.	N.A.	-
NLI-10/24	194,000	stainless	16	.75,6,2	96.0	45.0	204.5	balsa	70	both	71-9023
BR-100	202,000	stainless	32 2.5”	1.0,4.5,1.75	82	58.5	202	wood	15	elast.	-
Modal Study		stainless	N.A.	0.5,5.25,1.5	52	37.5	193	yes	3.4-24	N.A.	-
Generic	**225,000**	**stainless**	**24 1.75”**	**1.0,4.5,2.0**	**80**	**65**	**200**	**yes**	**24**	**elast.**	**-**

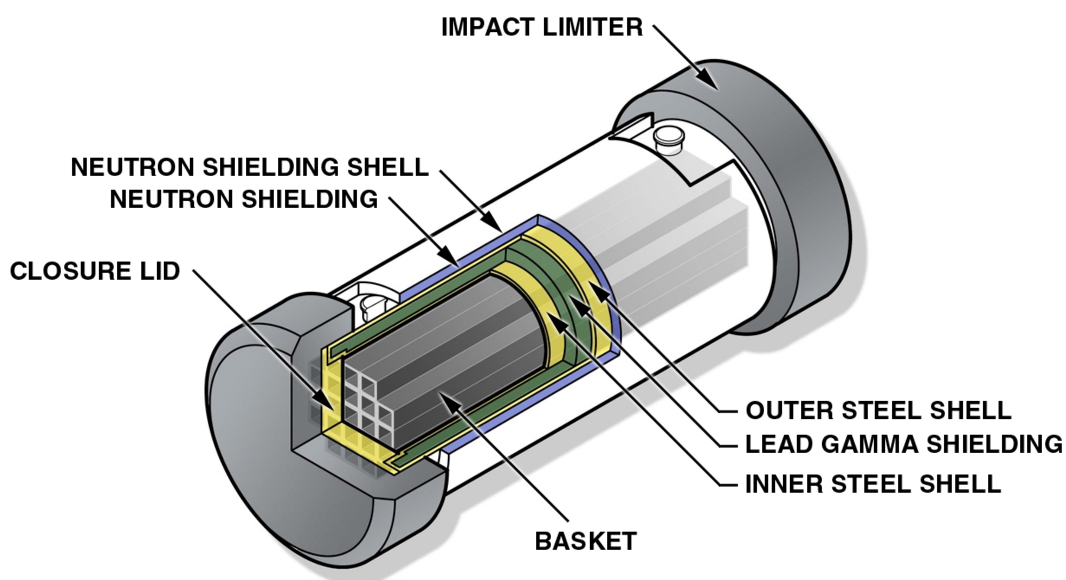

Figure 4.3 Conceptual design of a generic steel-lead-steel rail cask.

Table 4.4 Monolithic Rail Casks

Name	Weight (pounds)	Material	Closure Bolts (no./size)	Wall Thickness (inches)	Outside Diameter (inches)	Cavity Diameter (inches)	Length (inches)	Impact Limiter	Design Heat Rejection (kW)	Seal Material	C of C
TN-24**	224,000	SA-350	N.A.	9.5	92.4	57.25	186.8	none	24	metal	72-1005
REG	225,000	SA-350	48 1.625”	9.25	90.25	71.25	180	redwood	2.7	both	71-9206
BRP	215,000	SA350 LF3	48 1.625”	9.62	83.25	64	190.5	redwood	3.1	both	71-9202
Hi-Star 100	244,000	ferritic steel	N.A.	13.6	95.9	68.75	202.9	?	23.4	N.A.	71-9261*
C-E Dry Cap	224,000	Steel	N.A.	12.7	90.0	64.6	196.9	none	N.A.	N.A.	-
TN-12	144,800	ferritic steel	40 1.65”	15.9	78.74	33.2	210	wood	120	elast.	-
Castor-V/21**	234,000	NCI	N.A.	15.0	93.9	60.1	192.4	none	28	metal	72-1000
Generic	**224,000**	**stainless steel**	**24 1.75”**	**10**	**85**	**65**	**190**	**yes**	**24**	**elast.**	**-**

* Certificate pending

** These casks are only licensed for storage in the U.S. but are used for transportation in other countries.

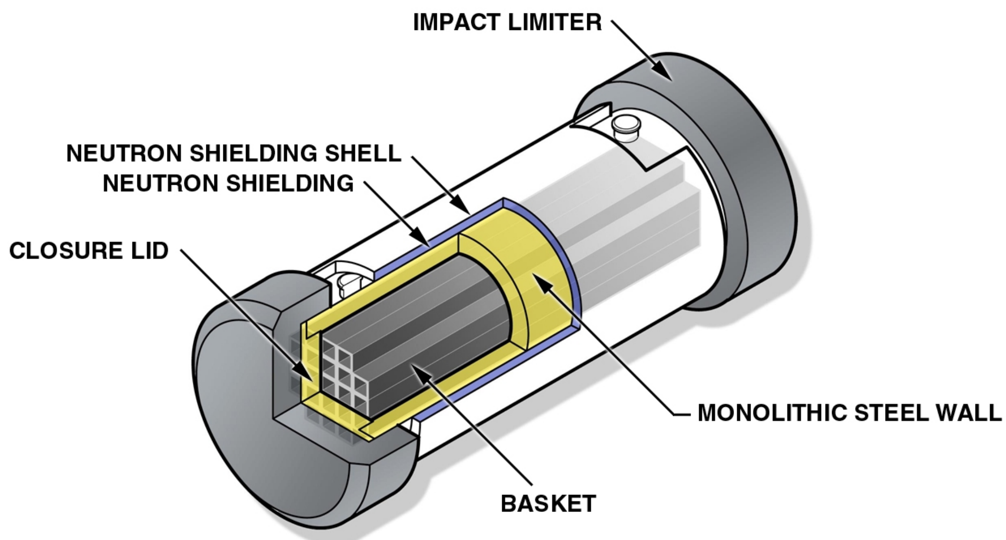

Figure 4.4 Conceptual design of a generic monolithic steel rail cask.

The capacity of the generic casks was assumed to be 24 pressurized water reactor (PWR) or 52 boiling water reactor (BWR) assemblies for the steel-lead-steel and monolithic steel rail casks, 1 PWR or 2 BWR assemblies for the steel-lead-steel truck cask, and 3 PWR or 7 BWR assemblies for the steel-DU-steel truck cask. No attempt was made to specify a generic basket. It may not be physically possible to fit the assumed number of assemblies in the cavity volume of the generic casks. It may also be possible that the generic casks would not be suitable for the assumed number of assemblies for all conceivable fuel types that may be shipped. For example, the surface dose rate or internal temperatures may be too high for short-cooled high-burnup fuel.

The wall thickness listed in the tables does not include neutron shielding, which is generally in the central region of the cask and outside of the containment system of the walls. The neutron shielding does not contribute significantly to the strength of the cask. Therefore, ignoring it will have little effect on the results of the structural modeling discussed in the following chapter. In the structural finite element model, the weight of the neutron shielding and its liner are added to the contents so that the total weight of the package is correct. For the thermal analyses a neutron shield consisting of 4.5 inches of water (considered empty in the analyses) contained by a 0.25-inch steel shell is assumed for all of the casks. Even though most modern casks use a solid neutron-shielding material, the thermal analyses assumed that an empty neutron-shielding layer would provide a more conservative assessment of the heating of the cask for cases where the fire does not follow a severe impact that collapses the neutron shielding tank, thereby eliminating the 4.5 inch air gap.

In other aspects of the cask construction where there is a major difference between older casks and newer casks, the generic casks specifications more closely simulated the newer designs. Many of the older casks are of designs where additional packages cannot be built, so a fleet of these casks will not be used for a major transportation campaign. For all casks to be used in transportation it is assumed there will be an impact limiter. The information available about the impact limiters was not sufficient to develop a generic design, but it will be assumed that the regulatory impact (9-m free drop onto an unyielding target) uses the full amount of energy absorbing capacity of the impact limiter prior to the lock-up region of the force-deflection curve. For all of the structural analyses, the finite element model includes an impact limiter that has been fully crushed in all directions.

All of the generic casks are assumed to have elastomeric o-ring seals inboard of the bolt location. It is possible, using the results of the finite element analysis in the next section, to derive source-terms for casks with metallic seals in addition to the source-terms derived for the casks with elastomeric seals, but this has not been done. The closure on all of the casks is recessed into the cask body, with a face-seal configuration. Figure 4.5 shows the lid of one of the casks and the location of the bolts. This type of closure is the most common configuration used in spent fuel casks, but other configurations are seen. For example, the 125-B cask uses bore seals instead of face seals.

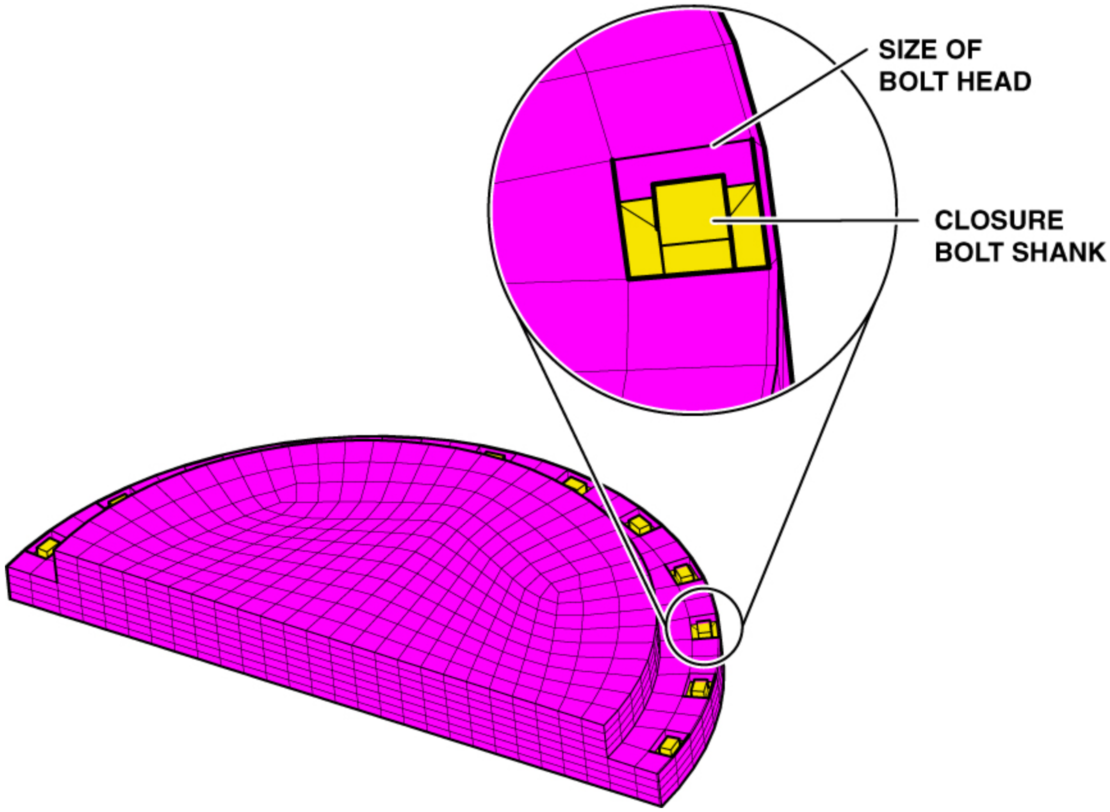

Figure 4.5 Finite element representation of a typical closure lid for structural analysis, showing the locations of the bolts.

4.2 Conservatism in Cask Selection

The specifications of the generic casks for this study were defined with the intent of producing a conservative analysis. That is, a design that is more likely to develop a leak path and lose containment integrity than any of the certified/planned designs listed.

All of the sandwich wall generic casks have shell thicknesses that are less than those of modern designs. Thicker shells result in smaller deformations, lower probabilities of puncture, and reduced lead slump. For the rail casks the number of bolts chosen for the generic design is lower than the number being used for modern designs. Increasing the number of bolts decreases the closure openings, resulting in reduced probabilities for radioactive material release.

Although generic specifications are likely to lead to conservative results, it should not be assumed that designs with similar dimensions could not be implemented in a real cask that could gain certification by the NRC.

4.3 References

[4.1] JAI Corporation, “Shipping and Storage Cask Data for Commercial Spent Nuclear Fuel,” JAI-421, Fairfax, VA, July 1996.

[4.2] US Nuclear Regulatory Commission, “Fracture Toughness Criteria of Base Material for Ferritic Steel Shipping Cask Containment Vessels with a Wall Thickness Greater Than 4 inches (0.3m),” Regulatory Guide 7.12, June 1991.